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THE QUEENSLAND JOURNAL OF AGRICULTURAL SCIENCE

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OBSERVATIONS ON THE GRAZING BEHAVIOUR OF BEEF CATTLE IN TROPICAL QUEENSLAND.

By R. M. LARKIN, H.D.A., Adviser, Cattle Husbandry Branch, Division of Animal Industry.

SUMMARY.

The results of a series of observations on the habits of Shorthorn steers grazing on improved tropical pastures at South Johnstone and Ayr, on the north-eastern coast of Queensland, are presented.

The average times spent per day in various activities by a group of 16 cattle observed on a total of 15 days at South Johnstone were—grazing 7.27 hours, loafing 6.52 hours, lying down 10.21 hours.

The average times for observations made on 10 days at Ayr were—grazing 7.27 hours, loafing 6.33 hours, lying down 10.40 hours.

It is concluded that high temperatures reduce the amount of daytime grazing, restrict the total grazing time, cause long periods to be spent in shade, and restrict the time spent lying down.

I. INTRODUCTION.

A recent review of the literature on the grazing behaviour of cattle made by Hancock (1953) indicates that, while much information has been collected on the habits of cattle, particularly dairy cattle, in temperate regions, very few studies have been made in tropical regions.

Seath and Miller (1946), in observations on Jersey and Friesian cows in Louisiana (U.S.A.), observed that day time grazing was greatly reduced on hot days and night grazing increased. They also observed an overall decrease in total grazing time when high temperatures prevailed.

Payne, Laing and Raivoka (1951) made a study of the behaviour of Friesian cows in Fiji and concluded that their habits were entirely different from those of European cattle in temperate regions. They found that 67% of a cow's grazing time took place at night, compared with 28% found by Hancock (1950) in New Zealand.

The author has seen no record of studies of the grazing behaviour of beef cattle of British breeds in a tropical environment.

The studies reported here were conducted at two centres in tropical Queensland—the Bureau of Tropical Agriculture at South Johnstone, and Ayr Regional Experiment Station.

The Bureau of Tropical Agriculture is situated in the wet tropical coastal belt, being located at longitude 146° 10′ E, latitude 17° 40′ S. The average annual rainfall recorded at the Bureau is 120 inches, but the precipitation varies from 80 to 180 inches per annum. Approximately 75% of the rainfall is received in the period January–July, and by far the heaviest falls are recorded in February and March. From August to November conditions are relatively dry. December rainfall is very variable, depending on storms. The maximum temperature rarely exceeds 90°F. during the summer months; temperatures may fall as low as 40° in winter. The humidity is generally high throughout the year.

The Ayr Regional Experiment Station is situated at longitude 147° 23′ E, latitude 19° 36′ S (height above sea level 34 ft.). The average annual rainfall of the area is 40 inches, of which about 30 inches are received in the period December to March, the remaining part of the year being normally dry. Summer temperatures often exceed 90°F., and each year light frosts are likely to be experienced in lowlying areas. For a tropical coastal area, humidity throughout the year is relatively low.

II. OBSERVATIONS AT SOUTH JOHNSTONE.

The observations at this station were made in October 1952, December 1952, February 1953, April 1953 and June 1953.

1. Experimental Conditions and Technique.

(a) Cattle.

Sixteen grade Shorthorn steers in store condition were selected as the experimental animals. These had been brought onto the property two months previously and were approximately 2½ years of age. During the period of two

months prior to the beginning of observations, they had settled down on the new pasture and gained appreciably in weight. Their average weight increased over the period of observation from 874 lb. to 1,164 lb.

(b) Pasture.

The pasture area was made up of a number of 2-acre paddocks which contained mixtures of grasses and legumes undergoing trial to test their suitability for use in improving tropical pastures. The pasture mixtures were grazed rotationally, each paddock being grazed for 3–4 days and then given 31–32 days' spell before the next grazing. The stocking rate was maintained at the rate of 4 beasts to 5 acres. The paddocks were served by a laneway in which shade and water were available, and to which the stock had free access.

Pasture conditions varied during the trial. There was, however, always an abundance of feed, though its quality varied. A brief account of the pasture at each observation follows. In all instances desirable pasture species constituted a complete cover.

Date.	Pasture Conditions.
28-10-52	Paddock made up of areas of para grass (*Brachiaria mutica*) and molasses grass (*Melinis minutiflora*) to an average height of 15 in., consisting of some young growth and much older material. Puero (*Pueraria phaseoloides*) in close association with the grass and mostly of older growth.
28-12-52	Young fresh shoots of molasses grass to 6 in. in height overlying a mat of dry material. Puero closely intermingled with the grass and presenting a flush of young growth.
24-2-53	Purple top guinea grass (*Panicum maximum* var. *coloratum*) presenting a substantial amount of fresh growth to 3 ft. in height. Centro (*Centrosema pubescens*) presenting abundant young growth in association with the grass.
28-4-53	Para grass in association with centro providing good feed 18 in. to 2 ft. high; otherwise paddock a dense mat of puero and centro to a depth of 15 in.
23-6-53	Leafy molasses grass to 12 in. high, with some old seedheads still evident. Calopo (*Calopogonium mucunoides*) and centro in association and in patches predominating; some leafy growth evident and both species in flower.

(c) Weather.

Weather conditions varied widely over the trial. Table 1 gives briefly some of the details.

Table 1.

WEATHER CONDITIONS AT SOUTH JOHNSTONE.

Date.	Max. Temp. (°F.)	Min. Temp. (°F.)	Relative Humidity 9 a.m.	Rainfall to 9 a.m. (in.)	Remarks.
28-10-52	91	70	71	..	Hot, light breeze
29-10-52	90	72	64	·01	Hot, humid, showers 2 a.m. and 5 a.m.
30-10-52	90	73	91	..	Hot, cool afternoon breeze
31-10-52	89	73	68	..	Hot, cool breeze at mid-day
28-12-52	86	73	75	·17	Warm—heavy rain 2 p.m. to 4 p.m.
29-12-52	86	70	91	1·70	Showery 5 a.m. to 10 a.m. Warm with cool breeze
30-12-52	88	70	64	·02	Hot with cool night
31-12-52	90	69	64	..	Hot with cool breeze in late afternoon
24-2-53	90	72	79	·61	Hot with showers at 1.30 p.m. and 3 p.m. to 5 p.m.
25-2-53	90	72	74	·24	Hot and humid, rain 10.30 p.m. to 11 p.m.
26-2-53	88	72	82	·40	Warm, no breeze. Shower at 3 p.m.
27-2-53	89	70	78	·01	Warm clear day
28-4-53	82	62	90	·01	Hot and sunny—shower at 9.45 p.m.
29-4-53	84	66	86	·07	Warm with cool breeze. Cool night
30-4-53	84	66	90	·06	Shower 12.30 a.m. and 10 p.m. Cloudy cool day
1-5-53	85	64	81	·01	Warm to hot with no breeze
23-6-53	71	43	74	..	Cool with strong breeze. Cold night
24-6-53	73	50	83	..	Cool to warm with intermittent cool breeze
25-6-53	76	52	83	..	Warm, some cloud and light breeze
26-6-53	76	54	89	..	Warm and sunny

(d) Recording Technique.

(1) Observations were made for three consecutive 24-hour periods at intervals of two months and were commenced 24 hours after the steers had access to a new paddock, which period was allowed for settling down. The observations then continued for the next three days.

(2) Recordings were made every five minutes throughout the 24 hours, the method being to record the number of steers engaged in the various activities at the end of each 5-minute period.

These activities were classified as follows:—

(*a*) Grazing—all the time spent in gathering herbage, including the time involved in selection of the herbage.

(*b*) Loafing—all the time spent standing, walking from shade and water, rubbing, fighting and drinking.

(*c*) Lying down—all the time spent lying down.

Differentiation as to whether these three habits were pursued in or out of the shade was also made. In addition, drinking habits were observed.

No attempt was made to record the time occupied in ruminating, defecating or urinating.

In making the calculations, it was assumed that stock engaged in any activity at the end of the 5-minute period had been engaged in that activity for the whole of the 5 minutes.

2. Observations and Discussion.

(a) Grazing, Loafing and Lying Down.

The average times recorded per steer over each of the 3-day periods are presented in Table 2. Over the five observation periods, the average was:—

Grazing .. .. 7·27 hours.

Loafing .. .. 6·52 hours.

Lying down .. .. 10·21 hours.

Table 2.

AVERAGE ACTIVITIES OVER THE 3-DAY PERIOD (HOURS)—SOUTH JOHNSTONE.

Activity.	October.		December.		February.		April.		June.	
	Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.
Grazing ..	6·43	0·01	6·52	0·11	7·67	0·01	7·03	0·10	8·48	..
	6·44		6·63		7·68		7·13		8·48	
Loafing ..	2·29	6·05	2·15	4·29	2·85	4·98	3·04	3·23	3·75	..
	8·34		6·44		7·83		6·27		3·75	
Lying Down	4·33	4·90	6·39	4·55	5·19	3·30	7·60	3·01	11·78	..
	9·23		10·94		8·49		10·61		11·78	

The day-to-day figures recorded for the group are presented in Tables 3, 4 and 5, and show considerable difference in average group activity from day to day.

Table 3.

AVERAGE TIME SPENT PER STEER IN GRAZING (HOURS)—SOUTH JOHNSTONE.

Day.	October.		December.		February.		April.		June.	
	Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.
1	5·15 ..		6·79	0·03	9·14 ..		6·34	0·02	8·03 ..	
	5·15		6·82		9·14		6·36		8·03	
2	7·47	0·02	6·76	0·06	5·98	0·01	7·71	0·07	9·16 ..	
	7·49		6·82		5·99		7·78		9·16	
3	6·67 ..		6·02	0·23	7·89	0·03	7·03	0·20	8·25 ..	
	6·67		6·25		7·92		7·23		8·25	
Average ..	6·43	0·01	6·52	0·11	7·67	0·01	7·03	0·10	8·48 ..	
	6·44		6·63		7·68		7·13		8·48	

Table 4.

AVERAGE TIME SPENT PER STEER IN LOAFING (HOURS)—SOUTH JOHNSTONE.

Day.	October.		December.		February.		April.		June.	
	Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.
1	3·33	6·77	3·37	3·56	1·83	6·01	4·20	3·75	3·49 ..	
	10·10		6·93		7·84		7·95		3·49	
2	1·71	6·25	0·98	4·50	3·57	4·94	1·83	3·33	3·23 ..	
	7·96		5·48		8·51		5·16		3·23	
3	1·84	5·12	2·10	4·80	3·14	3·99	3·09	2·60	4·52 ..	
	6·96		6·90		7·13		5·69		4·52	
Average ..	2·29	6·05	2·15	4·29	2·85	4·98	3·04	3·23	3·75 ..	
	8·34		6·44		7·83		6·27		3·75	

October.—It will be noted that during October there was a wide variation in grazing time with consequent variation in periods occupied in loafing and lying down. It may be that the sudden onset of hot weather after a long interval of mild weather was responsible for the low figure (5·15 hours) recorded for grazing on the first day. The discomfort as evidenced by the protracted period spent loafing (10·1 hours) tends to support this idea. The short grazing period was, however, offset by a long grazing period next day with a corresponding decrease in loafing time. On the third day, the cattle seemed to be more accustomed to the hot conditions, and longer intervals were spent lying down (mean 10·38 hours) with a further decrease in loafing time and a figure for grazing which was intermediate between those of the two previous days.

Table 5.

AVERAGE TIME SPENT PER STEER IN LYING DOWN (HOURS)—SOUTH JOHNSTONE.

Day.	October.		December.		February.		April.		June.	
	Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.
1	3·86	4·90	7·57	2·69	4·71	2·31	7·25	2·44	12·48	..
	8·76		10·26		7·02		9·69		12·48	
2	4·55	4·01	6·57	5·13	6·25	3·25	7·13	3·94	11·61	..
	8·56		11·70		9·50		11·07		11·61	
3	4·58	5·80	5·02	5·83	4·62	4·35	8·42	2·66	11·24	..
	10·38		10·85		8·97		11·08		11·24	
Average ..	4·33	4·90	6·39	4·55	5·19	3·30	7·60	3·01	11·78	..
	9·23		10·94		8·49		10·61		11·78	

December.—During December, despite a wide difference in weather conditions, over the 3–day period there was very little difference in the day-to-day behaviour. There was a slight decline in grazing time on the third day, but this may have been due to a slightly higher temperature. The amount of grazing time in the shade on the third day (0·23 hours), although not of great magnitude, is quite considerable when compared with similar figures recorded for other months of the year.

February.—The weather in February was hot and humid, with showers making conditions quite uncomfortable. There were wide daily differences in all activities. The long grazing period of the first day was balanced by decreased grazing on the following day, with an increase in loafing and lying down. The fact that stands out most is the increased grazing time over that observed in October and December; this is associated with a decline in time spent lying down.

April.—In April, the times spent in the various activities on the first day differed greatly from the other two days, the figures for which are very similar. Generally the weather was cooler than in February. There was, however, a slight decrease in grazing time from that observed in February, but lying down time was greatly increased.

June.—In June, the weather was cooler than previously and this is reflected in the figures obtained. Times spent in grazing and lying down were the highest observed (viz., 8·48 hours and 11·77 hours respectively) and loafing time was reduced accordingly.

(b) Pattern of Activities.

The pattern depicted in Fig. 1 for each of the periods of observations is—

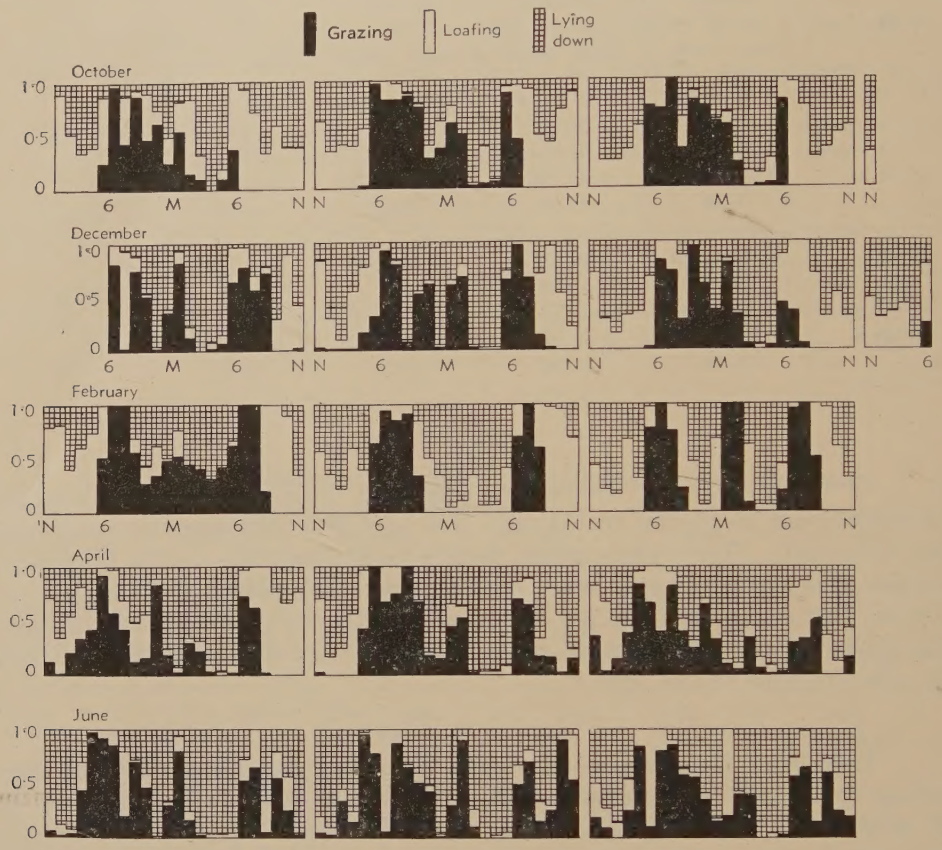

Fig. 1.

Observations at South Johnstone.

(M and N represent midnight and noon respectively.)

October.—The first day shows spasmodic periods of heavy grazing and a markedly short morning grazing period, but the second and third days differ and show three peak grazing periods—evening, night and early morning. It will be seen that very little grazing occurred in October after 6 a.m. The daytime is divided into similar periods of loafing and lying down, and at night, except on the first day, most of the time not spent grazing is devoted to lying down.

December.—For December, four main grazing cycles are present—evening, before midnight, after midnight and early morning. The intensity of these grazing periods varies over the three days. The previous general pattern of loafing and lying down is again evident.

February.—Three grazing cycles are exhibited for February. However, the midnight grazing cycle was omitted on the second day, when only two periods of grazing were observed. Generally more of the daylight hours than was observed previously were spent loafing.

April.—Very spasmodic grazing was evident on the third day of observations in April and the pattern exhibited for this occasion differs somewhat from that of the previous two days.

A further feature is the tendency for grazing to commence earlier in the afternoon.

June.—Shorter periods of loafing are evident in June and the grazing period has markedly changed. An important grazing cycle now occurs in the afternoon, while the morning cycle is divided into two shorter periods, one in the early morning and the other extending to approximately midday. Two grazing periods at night are still evident, but these are of shorter duration.

(c) Distribution of Grazing Time.

The distribution of grazing time throughout the day is a reflection of the manner in which cattle adapt themselves to high temperatures. Table 6 shows the length of time spent at grazing and the percentage of the daily grazing time for two periods of the day—from 4 p.m. to 8 a.m. and from 8 a.m. to 4 p.m. These intervals were selected because it was considered that prior to 8 a.m. and after 4 p.m., temperature in the main would not be a limiting factor to grazing.

October.—It will be seen from Table 6 that during October all grazing occurred between 4 p.m. and 8 a.m., this being attributed to the sudden onset of hot weather.

December.—In December, when the weather varied over the three days, the distribution of grazing time also varied. The first day was cloudy with showers and 21·8% of the grazing occurred between 8 a.m. and 4 p.m. Though the total grazing time on the third day was similar, no grazing occurred between 8 a.m. and 4 p.m.

February.—During February, there was a tendency for grazing to occur between 8 a.m. and 4 p.m., 10·2% of the time on one of the three days being so occupied.

April.—April saw a further increase in the tendency to graze between 8 a.m. and 4 p.m. This was partly attributable to the showery and cloudy conditions which prevailed, particularly on the third day, when over 20% of this period was devoted to grazing.

June.—In June, temperatures were much lower and a greater proportion of the total grazing occurred between 8 a.m. and 4 p.m. On one day up to 26·4% of the period was spent grazing, and the average for the three days was 22%.

Table 6.

Average Time Spent per Steer in Grazing (Hours)—South Johnstone.

	October.		December.		February.		April.		June.	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
Day 1 ..	5·15	..	6·02	0·80	8·94	0·20	5·63	0·73	6·61	1·42
Percentage..	100·0	..	88·3	11·7	97·8	2·2	88·5	11·5	82·3	17·7
Day 2 ..	7·49	..	6·66	0·16	5·38	0·61	7·28	0·50	6·76	2·41
Percentage..	100·0	..	97·7	2·3	89·8	10·2	93·6	6·4	73·7	26·3
Day 3 ..	6·67	..	6·25	..	7·39	0·53	5·65	1·58	6·47	1·78
Percentage..	100·0	..	100·0	..	93·3	6·7	78·1	21·9	78·4	21·6
Average ..	6·44	..	6·31	0·32	7·24	0·44	6·19	0·94	6·61	1·87
Percentage ..	100·0	..	95·2	4·8	94·3	5·7	86·8	13·2	77·9	22·1

A = 4 p.m. to 8 a.m. B = 8 a.m. to 4 p.m.

(d) Time Spent in Shade.

Cattle normally seek shade when the heat becomes uncomfortable—this often occurs in the tropics and subtropics.

Data relating to the average total time spent in the open and in the shade, irrespective of the animals' activities, are presented in Table 7.

It can be seen that over the period the average time spent in the shade varied from nearly 11 hours per day to nil.

In October, when temperatures were high, the cattle made use of shade for over 40% of the day. In December, just on one-quarter of the first day was spent in the shade; this day was showery and cloudy. On the next two days, when conditions changed, over 40% of the time was spent in the shade. During February, there was a further general decline in the time during which the cattle sought shade, and though temperature conditions were very similar to those prevailing in October, considerably less use was made of shade. The lower temperatures of April induced cattle to seek shade less than previously, though there was a day-to-day variation. In June, the steers were quite content to graze, loaf, or lie down in the paddock without attempting to seek shade.

It can be seen from a perusal of Tables 2 to 5 that very little time was spent grazing in the shade. This is understandable, as feed that was growing in the shade was soiled because of the high concentration of cattle.

Table 7.

AVERAGE TIME SPENT PER STEER IN OPEN AND SHADE IRRESPECTIVE OF ACTIVITIES (HOURS) —SOUTH JOHNSTONE.

	October.		December.		February.		April.		June.	
	Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.
Day 1 ..	12·34	11·67	17·73	6·28	15·68	8·32	17·79	6·21	24·00	..
Percentage in Shade	..	48·6	..	26·2	..	34·7	..	25·9	..	..
Day 2 ..	13·73	10·28	14·31	9·69	15·80	8·20	16·67	7·34	24·00	..
Percentage in Shade	..	42·8	..	40·4	..	34·2	..	30·6	..	..
Day 3 ..	13·09	10·92	13·14	10·86	15·65	8·37	18·54	5·46	24·00	..
Percentage in Shade	..	45·5	..	45·3	..	34·9	..	22·8	..	..
Average..	13·04	10·96	15·06	8·94	15·71	8·30	17·67	6·34	24·00	..
Percentage in Shade	..	45·7	..	37·3	..	34·6	..	26·4	..	..

The only tendency for the group to graze in the shade to any extent was on the third day of observation in December.

There does not appear to be any relationship between the amount of time occupied in loafing or lying down in the open and that in the shade.

(e) Number of Drinks.

The average number of drinks taken per steer on each day is recorded in Table 8.

Table 8.

NUMBER OF DRINKS PER STEER—SOUTH JOHNSTONE.

Day.	October.	December.	February.	April.	June.
1	1·75	0·88	0·31	0·75	0·56
2	1·56	1·13	0·88	0·50	0·88
3	2·06	1·00	1·00	0·75	0·88
Average ..	1·79	1·00	0·73	0·67	0·77

The highest figures were for October, when temperatures were high. The difference in drinking habits between February and October is quite marked despite the fact that similar temperature conditions prevailed; the

occurrence of some showers of rain and heavy dews in February may account for this difference.

Drinking habits over the months of February, April and June were comparable.

III. OBSERVATIONS AT AYR.

Observations were made at Ayr Regional Experiment Station in November 1952, January 1953, March 1953, May 1953 and June 1953.

1. Experimental Conditions and Technique.

(a) Cattle.

A group of 6–7 grade Shorthorn steers in store condition, from two to three years of age and of the same origin as those selected in the South Johnstone trial, were used. Before observations commenced, the cattle had settled down and were making good weight gains. Liveweights are given in Table 9.

Table 9.

LIVEWEIGHT OF CATTLE (POUNDS) AT TIME OF OBSERVATIONS—AYR.

Steer No.	November.	January.	March.	May.	July.
52 ..	..	790	816	..	..
56 ..	873	944	1,005	1,067	1,150
29 ..	948	1,026	1,110	1,150	1,185
43 ..	809	839	897	959	993
51 ..	807	904	949	1,010	1,048
41 ..	979	1,092	1,131	1,158	1,142
54 ..	880	966	1,005	1,032	1,055
Average ..	883	937	988	1,063	1,096

(b) Pastures.

The pasture consisted of a mixture of guinea grass (*Panicum maximum* var. *typica*) and stylo (*Stylosanthes gracilis*), under irrigation. Rotational grazing was practised, allowing one week of grazing and three weeks of rest. A minimum stocking rate of 6 beasts per 5 acres was held, this being increased when the pasture was lush.

The area was divided into paddocks of 1·25 acres, and water was available in troughs. In November and March, no shade was provided, but a brush shelter provided shade during January, May and July.

Brief details of the pasture follow.

Date.	Brief Description.
26-11-52	Guinea grass giving good ground cover and carrying up to 20 in. of thick, soft young flush. Stylo mainly confined to interstool spaces and carrying 6–10 in. of young growth.
28-1-53	Heavy growth of guinea grass 3–4 ft. high, some of which is coarse growth. Stylo soft and leafy, giving a mat-like ground cover and mixed with the grass stools.
25-3-53	Heavy growth of guinea grass with seedheads to 5 ft. high, the more palatable material being only 2 ft.–2 ft. 6 in. high. Soft leafy stylo giving good ground cover and mixed with the grass stools.
27-5-53	Fresh guinea grass growth 12–15 in. long arising from coarse tussocks 12–15 in. high. Stylo giving good bulky growth of green material up to 14 in. high.
22-7-53	Young guinea grass growth 12–14 in. high arising from and around the coarse tussocks. Stylo confined mainly to interstool spaces and carrying 6–10 in. of young growth.

Table 10.

– Weather Conditions at Ayr.

Date.	Max. Temp. (°F.)	Min. Temp. (°F.)	Rainfall to 9 a.m. (in.)	Remarks.
26–11–52	88	71	..	Warm to hot. Variable breeze
27–11–52	89	75	..	Warm to hot. Cool afternoon breeze
28–11–52	96	70	..	Hot, intermittent light breeze
28–1–53	85	73	3·29	Warm to hot, light S.E. breeze, cloudy
29–1–53	85	72	·01	Warm, cloudy, cool S.E. breeze
30–1–53	81	73	·03	Cool, cloudy, showery from 9 a.m.
25–3–53	84	65	·09	Overcast, warm sunny afternoon
26–3–53	87	65	..	Hot and humid—rain 3.45 p.m. to 4.30 p.m.
27–3–53	81	73	·28	Rain 4 a.m. Cloudy and cool with S.E. breeze
27–5–53	79	42	..	Warm with light breeze—cold night
28–5–53	81	42	..	Warm to hot—gusty breeze—cold night
29–5–53	82	39	..	Warm to hot—variable S. breeze
22–7–53	77	46	..	Warm and sunny—cool to cold night
23–7–53	79	49	..	Warm, strong E. breeze—cool to cold night
24–7–53	77	48	..	Warm, with cool variable breeze

(c) Weather.

The weather varied somewhat during the course of the trial. Tables 10 and 11 provide some information on temperature, rainfall, humidity, etc.

Table 11.

RELATIVE HUMIDITY AT VARIOUS TIMES DURING THE DAY—AYR.

Month.	Day.	Noon.	6 p.m.	6 a.m.
November ..	1 (26–27)	53	62	73
	2 (27–28)	59	59	90
January	1 (28–29)	68	78	90
	2 (29–30)	68	78	86
March	1 (25–26)	76	86	95
	2 (26–27)	66	95	86
May	1 (27–28)	34	87	92
	2 (28–29)	38	69	100
July	1 (22–23)	54	73	100
	2 (23–24)	38	73	92

(d) Recording Technique.

The following technique was followed:—

(1) Recordings were made for two consecutive 24-hour periods at intervals of two months and were commenced 24 hours after the cattle entered a new paddock.

(2) The individual animals were observed continuously, using the method described by Hancock (1950) with the modification that the path traversed by only one member of the group was recorded.

An endeavour was made to study urinating habits but the tall nature of the pasture precluded accurate observation.

2. Observations and Discussion.

(a) Grazing, Loafing, Lying Down.

The average period occupied by each activity over the five observation periods was:—

Grazing	.. ..	7·27 hours.
Loafing	.. ..	6·33 hours.
Lying down	.. ..	10·40 hours.

In Table 12 are recorded the average activities of each 2-day observation period. These figures are the mean values calculated for six steers in November, May and July and for seven steers in January and March. The individual day-to-day activities of each steer are presented in Tables 13–15.

Table 12.

AVERAGE ACTIVITIES (HOURS AND MINUTES) FOR 2-DAY OBSERVATION PERIOD—AYR.

Month.	Grazing.	Loafing. Open.	Loafing. Shade.	Lying Down. Open.	Lying Down. Shade.
November*	6 23	8 05	..	9 32	..
		8 05		9 32	
January	6 12	3 36	2 43	10 20	1 9
		6 19		11 29	
March*	5 05	9 53	..	9 02	..
		9 53		9 02	
May	9 55	1 44	1 39	9 11	1 31
		3 23		10 42	
July	9 22	2 10	1 13	10 36	0 39
		3 23		11 15	

* Shade not available.

Table 13.

TIME (HOURS AND MINUTES) SPENT PER STEER IN GRAZING—AYR.

Steer No.	Day.	November.*	January.	March.*	May.	July.
52	1	..	5 59	5 21	..	..
	2	..	6 04	5 34	..	..
56	1	6 38	5 46	5 45	11 14	8 39
	2	6 41	6 51	4 10	8 09	9 12
29	1	6 12	7 02	6 39	10 01	9 52
	2	7 13	7 25	4 16	9 23	9 06
43	1	6 16	5 26	4 23	10 36	10 56
	2	6 43	7 18	5 20	11 13	10 45
51	1	7 01	5 43	5 27	9 24	10 03
	2	6 17	6 29	4 03	9 25	8 07
41	1	4 33	6 14	5 11	10 36	10 00
	2	6 36	6 08	5 26	9 36	6 59
54	1	5 51	4 46	5 19	9 58	10 21
	2	6 34	5 27	4 18	9 19	8 17
Average	1	6 05	5 51	5 26	10 18	9 59
	2	6 41	6 32	4 44	9 31	8 44

* Shade not available.

Table 14.

TIME (HOURS AND MINUTES) SPENT PER STEER LOAFING—AYR.

Steer No.	Day.	November.*		January.		March.*		May.		July.	
		Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.
52	1	..	..	3 52	2 25	10 58	..	..	..	..	..
				6 17		10 58					
	2	..	..	5 57	0 28	7 51	..	..	..	..	..
				6 25		7 51					
56	1	7 27	..	4 27	2 40	11 39	..	1 17	1 09	3 17	1 19
		7 27		7 07		11 39		2 26		4 36	
	2	7 59	..	4 58	2 52	9 11	..	3 46	1 03	1 14	1 40
		7 59		7 50		9 11		4 49		2 54	
29	1	7 36	..	2 37	3 45	11 11	..	0 57	2 01	1 58	1 49
		7 36		6 22		11 11		2 58		3 47	
	2	8 52	..	3 11	3 19	9 05	..	3 01	1 41	0 59	1 43
		8 52		6 30		9 05		4 42		2 42	
43	1	7 28	..	3 03	3 11	11 36	..	0 35	0 59	1 20	0 26
		7 28		6 14		11 36		1 34		1 46	
	2	8 21	..	2 37	2 14	7 40	..	2 16	1 15	1 13	0 49
		8 21		4 51		7 40		3 31		2 02	
51	1	6 45	..	2 54	2 34	12 29	..	0 49	1 35	2 16	0 50
		6 45		5 28		12 29		2 24		3 06	
	2	8 33	..	3 41	2 33	8 54	..	1 55	2 16	1 52	2 10
		8 33		6 14		8 54		4 11		4 02	
41	1	7 45	..	2 21	2 48	10 41	..	0 48	1 48	2 48	0 51
		7 45		5 09		10 41		2 36		3 39	
	2	8 19	..	3 59	2 00	6 48	..	2 30	0 37	3 41	2 44
		8 19		5 59		6 48		3 07		6 25	
54	1	8 33	..	2 44	3 50	11 42	..	0 49	2 21	2 42	0 08
		8 33		6 34		11 42		3 10		2 50	
	2	9 29	..	4 12	3 13	8 35	..	2 07	3 02	2 43	0 04
		9 29		7 25		8 35		5 09		2 47	
Average	1	7 36	..	3 08	3 02	11 28	..	0 52	1 39	2 23	0 54
		7 36		6 10		11 28		2 31		3 17	
	2	8 35	..	4 05	2 23	8 18	..	2 36	1 39	1 57	1 32
		8 35		6 28		8 18		4 15		3 29	

* Shade not available.

November.—The group average figures for November show a slight increase in grazing time from the first to the second day, but the main change in activities between these two days is a reduction in time occupied in lying down and the increase in loafing time on the second day. It is considered that the higher temperatures prevailing on the second day may have been responsible, particularly as no shade was available.

January.—A longer lying down period was noted in January, though the day-to-day group activities did not vary to the same extent as in November.

Table 15.

TIME (HOURS AND MINUTES) SPENT PER STEER IN LYING DOWN—AYR.

Steer No.	Day.	November.*		January.		March.*		May.		July.	
		Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.	Open.	Shade.
52	1	..	..	10 50	0 54	7 41	..	..	..	..	..
				11 44		7 41					
	2	..	..	11 26	0 05	10 35	..	..	..	..	..
				11 31		10 35					
56	1	9 55	..	8 55	2 12	6 36	..	9 15	1 05	9 59	0 46
		9 55		11 07		6 36		10 20		10 45	
	2	9 20	..	7 26	1 53	10 39	..	10 00	1 02	9 19	2 35
		9 20		9 19		10 39		11 02		11 54	
29	1	10 12	..	10 11	0 25	6 10	..	9 53	1 08	9 57	0 24
		10 12		10 36		6 10		11 01		10 21	
	2	7 55	..	8 51	1 14	10 39	..	7 55	2 00	10 03	2 09
		7 55		10 05		10 39		9 55		12 12	
43	1	10 16	..	12 20	..	8 01	..	10 04	1 46	11 18	0 00
		10 16		12 20		8 01		11 50		11 18	
	2	8 56	..	10 36	1 15	11 00	..	8 34	0 42	10 57	0 16
		8 56		11 51		11 00		9 16		11 13	
51	1	10 14	..	12 49	..	6 04	..	10 23	1 49	10 51	0 00
		10 14		12 49		6 04		12 12		10 51	
	2	9 10	..	10 03	1 14	11 03	..	8 58	1 26	11 04	0 47
		9 10		11 17		11 03		10 24		11 51	
41	1	11 42	..	10 55	1 42	8 08	..	8 28	2 20	10 21	0 00
		11 42		12 37		8 08		10 48		10 21	
	2	9 05	..	8 44	3 09	11 46	..	8 11	3 06	9 38	0 58
		9 05		11 53		11 46		11 17		10 36	
54	1	9 36	..	12 00	0 40	6 59	..	9 37	1 15	10 49	0 00
		9 36		12 40		6 59		10 52		10 49	
	2	7 57	..	9 30	1 38	11 07	..	8 56	0 36	12 56	0 00
		7 57		11 08		11 07		9 32		12 56	
Average	1	10 19	..	11 09	0 50	7 06	..	9 37	1 34	10 32	0 12
		10 19		11 59		7 06		11 11		10 44	
	2	8 44	..	9 31	1 29	10 58	..	8 45	1 29	10 40	1 07
		8 44		11 00		10 58		10 14		11 47	

* Shade not available.

The grazing period was very similar to that observed previously, but lying down time was increased at the expense of loafing time. This is considered to be a direct result of the slightly lower temperatures which prevailed, together with the availability of shade.

March.—March temperatures were comparable with those of January, but average humidity was slightly higher. Shade was not available and a reduction in average grazing time, particularly on the second day, was evident.

Loafing and lying down periods for both days were very varied. The extended loafing periods observed during this month were a direct result of high temperature and humidity.

Lying down time was markedly reduced on the first day as a direct consequence of high temperatures and humidity. Increased lying down time on the second day was mostly due to a longer period being spent lying down at night than on the previous day.

May.—Temperatures, particularly during the night time, were lower than in March, and there was a marked increase in grazing time, mostly at the expense of loafing time.

July.—The average grazing time in July was slightly less than in May, but it was still longer than any recorded during the hotter months. Loafing time was not greatly different, but lying down time increased at the expense of grazing time.

(b) Pattern of Activities.

The average pattern of activities for the group at each observation is shown in Fig. 2.

In November, four main grazing periods are shown—midday, late afternoon-evening, night, and early morning. Much the same pattern is shown for both days. The pattern of loafing and lying down time varies somewhat, in that on the first day a large part of the morning was spent lying down and on the second day much longer was spent lying down during the night hours.

The afternoon-evening grazing period increased in January, whilst the morning and midday periods decreased. Grazing during the night also increased. All activities show a similar pattern for the two days.

There are extensive loafing periods in March, while grazing comprises two major phases with only a minor peak during the night. Increased lying down time on the second night is very evident, as also is the period spent lying down between 6 a.m. and noon, when cool cloudy conditions prevailed.

The patterns for May and July are very distinct in that loafing periods are very short and lying down periods correspondingly longer. Morning and afternoon grazing is most marked in May, with one or two minor peaks during the night hours. In July, intermittent grazing from 6 a.m. to 6 p.m. was recorded, with peaks in grazing activity occurring in the early morning, noon and afternoon. Night grazing was consequently reduced. Most of the night hours in May and July were occupied in lying down.

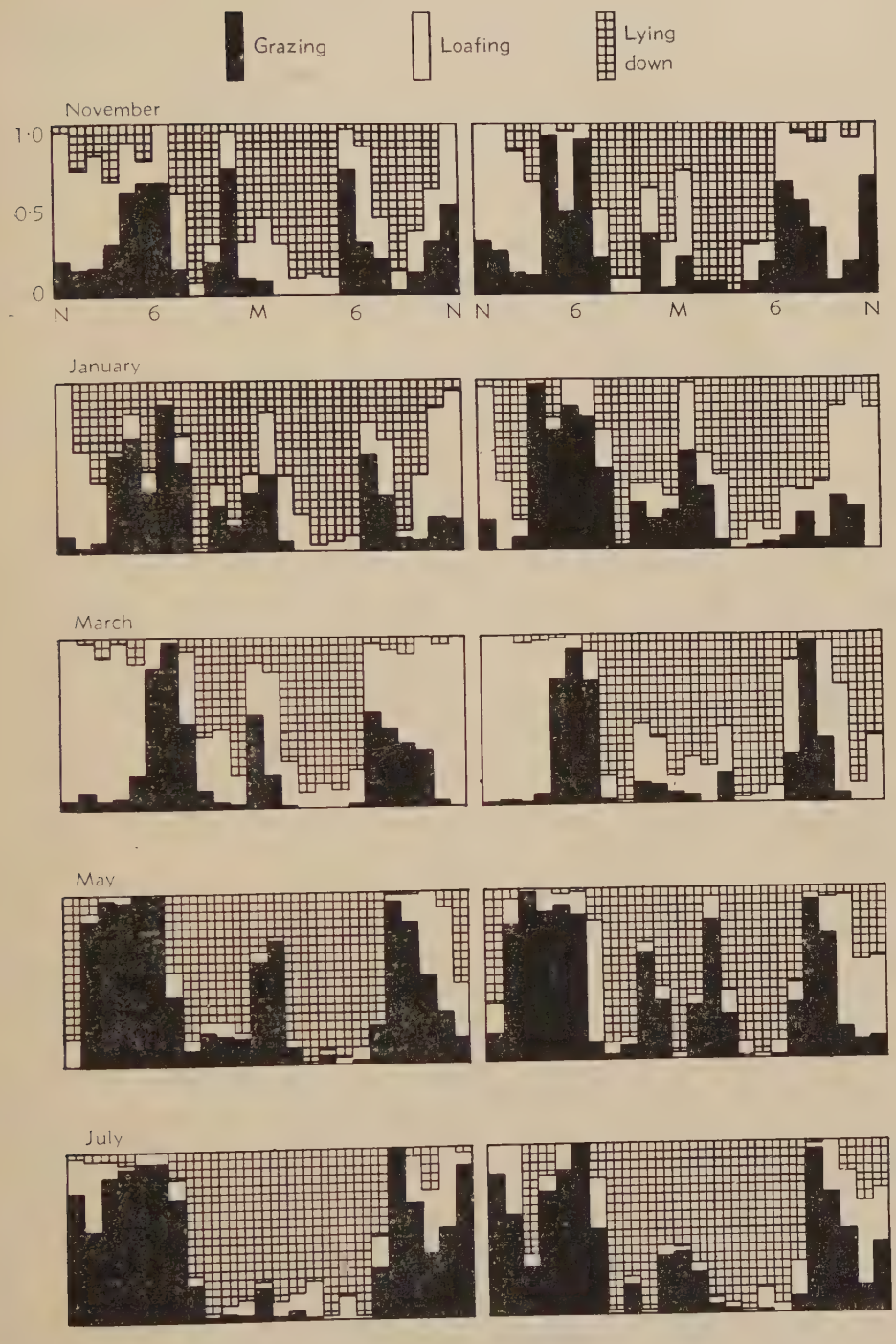

Fig. 2.

Observations at Ayr. (M and N represent midnight and noon respectively. Shade was available in January, May and July only.)

(c) Distribution of Grazing Time.

When considering the distribution of grazing time, it is seen that prevailing weather conditions exercise some influence (Table 16.)

Table 16.

AVERAGE TIME (HOURS) SPENT PER STEER IN GRAZING—AYR.

	November.		January.		March.		May.		July.	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
Day 1 ..	4·44	1·65	4·58	1·27	4·51	0·93	5·71	4·60	4·48	5·50
Percentage	72·8	27·2	78·3	21·7	82·9	17·1	55·4	44·6	44·9	55·1
Day 2 ..	4·59	2·09	4·73	1·79	4·17	0·56	5·57	3·94	4·57	4·17
Percentage	68·7	31·3	72·5	27·5	88·2	11·8	58·6	41·4	52·3	47·7
Average..	4·52	1·87	4·66	1·53	4·34	0·75	5·64	4·27	4·53	4·84
Percentage	70·7	29·3	75·3	24·7	85·3	14·7	56·9	43·1	48·3	51·7

A—4 p.m. to 8 a.m. B—8 a.m. to 4 p.m.

The day-to-day figures show, in some cases, considerable variation, but the effects of high temperatures are obvious. In November and January, approximately 70% of the grazing period occurred during the 4 p.m. to 8 a.m. period, with an increase in March to 85%, and it was at this stage that heat distress was marked. With the cooler weather in May and July, grazing in the same period was reduced to 56·9% and 48·6% respectively, with corresponding increases in grazing time during the 8 a.m. to 4 p.m. period.

(d) Time Spent in Shade.

Shade was not available to these animals in November and March, but was made available in January, May and July. Its absence materially influenced the behaviour of the cattle, particularly during the summer.

The provision of shade in January influenced lying down time during the daylight hours and, in conjunction with slightly lower temperatures, was a factor in causing more time to be devoted to lying down in January than in November.

With no shade available in March and more trying conditions than in previous months, grazing time was reduced below the November and January figures.

Reduced grazing on this occasion was a direct consequence of the unavailability of shade. Normally, when shade is available and temperature and humidity are high, cattle will loaf or lie down in the shade, and, as was observed at Ayr and particularly at South Johnstone, will compensate for time

lost grazing during the 8 a.m. to 4 p.m. period by grazing for long periods during the 4 p.m. to 8 a.m. period. On this occasion, cattle were uncomfortable during the day and did not graze or lie down. By nightfall they had become fatigued from incessant standing during the day and from increased metabolic efforts in their endeavour to maintain normal body temperature, and therefore preferred, as happened in this case, to lie down for most of the night.

In March, heat distress was very evident, being shown by increased respiration, protrusion of the tongue, excess salivation, aimless wandering and a perference for standing instead of lying down.

Less use was made of the shade in May than in January; this is understandable, as conditions were cooler. A further decrease was also evident in July, and on this occasion the use of shade by individuals showed a wide variation in that some steers did not seek shade at all on either day, whereas their companions spent up to $2\frac{3}{4}$ hours in the shade.

Whilst shade when made available was not used to the same extent as at South Johnstone, its importance as an influencing factor is stressed by the results observed. Figures presented in Table 17 show a reduction in the average daily use of shade from 3.88 hours in January to 1.87 hours in July.

Table 17.

AVERAGE TIME (HOURS) SPENT PER STEER IN OPEN AND SHADE IRRESPECTIVE OF ACTIVITIES —AYR.

—	November.	January.		March.	May.		July.	
		Open.	Shade.		Open.	Shade.	Open.	Shade.
Day 1 ..	No shade	20·13	3·87	No shade	20·77	3·23	22·91	1·09
Percentage in shade			16·1			13·5		4·5
Day 2 ..	No shade	20·13	3·87	No shade	20·87	3·13	21·35	2·65
Percentage in shade			16·1			13·0		11·0
Average ..	No shade	20·13	3·87	No shade	20·82	3·18	22·13	1·87
Percentage in shade			16·1			13·3		7·8

(e) Number of Drinks.

It will be seen from Table 18 that there were daily variations in the number of drinks taken, with most in November and fewest in July. The high average figure for the second day in May is due to the fact that steers Nos. 56 and 29 drank frequently, but at each time for a shorter period than was the case with other cattle.

Table 18.

NUMBER OF DRINKS RECORDED PER STEER—AYR.

Steer No.	Day.	November.	January.	March.	May.	July.
52	1	..	1	6	..	..
	2	..	4	1	..	..
56	1	4	2	3	2	3
	2	7	3	3	5	2
29	1	3	1	3	1	1
	2	5	4	2	6	1
43	1	2	..	2	..	2
	2	4	2	1	1	1
51	1	3	1	5	2	2
	2	3	3	1	2	1
41	1	3	1	2	2	2
	2	4	2	2	3	2
54	1	3	1	2	2	2
	2	2	2	1	2	1
Average	1	3·00	1·00	3·29	1·50	2·00
	2	4·17	2·86	1·57	3·17	1·33

Most drinks were taken between noon and 6 p.m., with occasional animals drinking during the morning or during the night. The usual procedure followed was to drink before commencing to graze after having been loafing or lying down or else to interrupt grazing for a short period to take a drink.

Table 19.

NUMBER OF DEFECATIONS RECORDED PER STEER—AYR.

Steer No.	Day.	November.	January.	March.	May.	July.
52	1	..	10	8	..	..
	2	..	9	9	..	..
56	1	9	14	7	7	6
	2	10	6	3	12	8
29	1	14	9	2	8	5
	2	14	9	8	8	3
43	1	8	8	9	7	5
	2	7	7	8	9	5
51	1	10	10	10	5	4
	2	11	12	5	10	4
41	1	11	8	6	6	10
	2	8	5	7	7	9
54	1	10	12	5	9	6
	2	9	9	8	12	8
Average	1	10·33	10·14	6·71	7·00	6·00
	2	9·83	8·14	6·86	9·67	6·17

The temperature of the drinking water was recorded after each steer drank. High water temperature did not prevent stock from drinking, as the highest temperatures—generally in the range of 80°-90°F. but sometimes as high as 100°F.—were recorded when most drinks were taken. Only a small proportion of drinks was taken during the night and early morning, when water temperature was as low as 61°F.

(f) Defecations.

The average number of defecations recorded per steer over the course of these observations was 8.05 per day. Considerable variation is evident in the figures presented in Table 19.

The variations over the different months are most marked. The lowest figure recorded was in July, with approximately 6 per day. A low figure was also recorded in March, when as a result of high temperatures and humidity a higher figure might have been expected. The reduced grazing period and consequent lowered feed intake may have been responsible. Individual and daily variations were most noticeable in the months of March, May and June.

(g) Distance Walked by Steer No. 54.

The average distance walked daily by steer No. 54 during the 10 days on which observations were made was 1,789 yards. Details are given in Table 20.

Table 20.

DISTANCE (YARDS) WALKED BY STEER No. 54—AYR.

Day.	November.	January.	March.	May.	July.
1	2,282	966	1,621	2,045	1,845
2	2,752	1,142	1,358	2,238	1,643
Average ..	2,517	1,054	1,489	2,142	1,744

Over any period, quality and quantity of a pasture will vary, and the distances registered from month to month as shown in Table 20 can be attributed to these factors.

Pasture growth in January and March was so abundant that the stocking rate was increased from 6 to 7 beasts per 5 acres. Even though pastures were then a little coarse owing to the rank growth of the "wet" season, the distance walked was at a minimum. In the other months, the pasture was not so abundant but was possibly of a higher quality, in that the main feed available was the flush growth produced by irrigation.

Figure 3 gives some idea of the coverage of the paddock made by this animal whilst grazing and walking about.

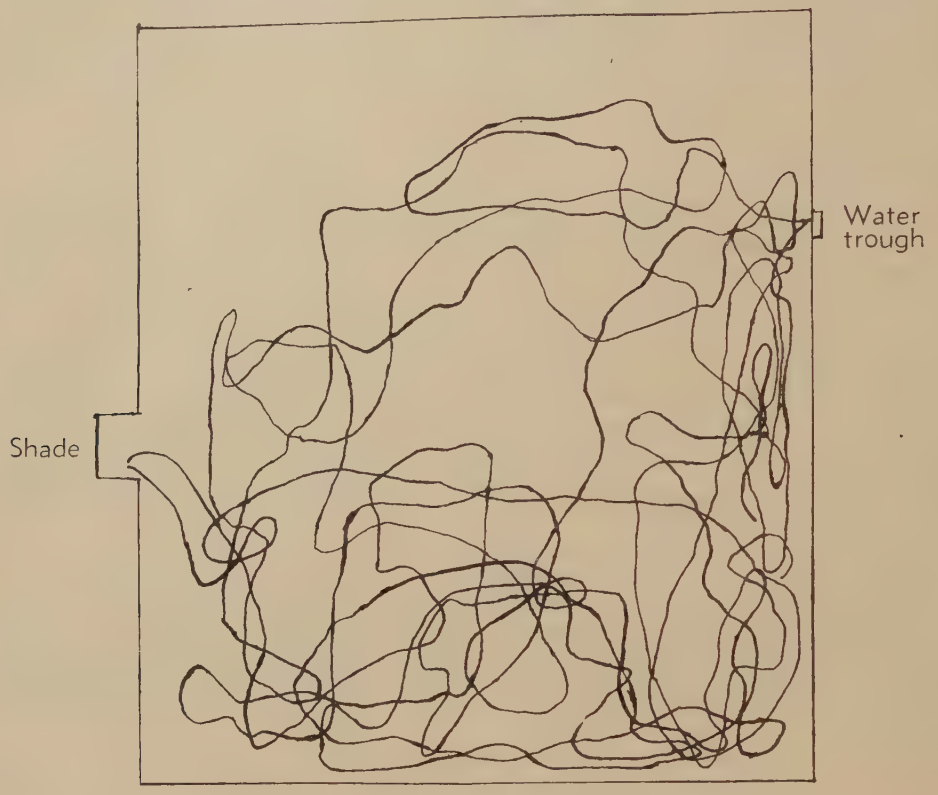

Fig. 3.

Track of Steer No. 54 on July 22-23, 1953.

(h) Individuality.

Wide variations were noted in the individual behaviour of different animals. This is emphasised in the summary (Table 21) of Tables 13-15, and the data presented in Tables 18 and 19.

The greatest variations between individuals in any one activity on any one day were:—

Grazing	.. ..	3 hours 46 minutes.
Loafing	.. ..	4 hours 23 minutes.
Lying down	.. ..	2 hours 34 minutes.

Whilst certain herd instincts apply generally, the actual distribution of activities over any one specific interval of time is influenced by idiosyncrasy.

Table 21.

RANGE OF TIME (HOURS AND MINUTES) DEVOTED TO VARIOUS ACTIVITIES ON EACH DAY OF OBSERVATION—AYR.

Month.	Day.	Grazing.	Loafing.	Lying Down.
November	1—A	4 33 7 01	6 45 8 33	9 36 11 42
	B	2 28	1 48	2 06
	2—A	6 17 7 13	7 59 9 29	7 55 9 20
	B	0 56	1 30	1 25
January ..	1—A	4 46 7 02	5 09 7 07	10 36 12 49
	B	2 16	1 58	2 13
	2—A	5 27 7 25	4 51 7 50	9 19 11 53
	B	1 58	2 59	2 34
March ..	1—A	4 23 6 39	10 41 12 29	6 04 8 08
	B	2 16	1 48	2 04
	2—A	4 03 5 34	6 48 9 11	10 35 11 46
	B	1 31	2 23	1 11
May	1—A	9 24 11 14	1 34 3 10	10 20 12 12
	B	1 50	1 36	1 52
	2—A	8 09 11 13	3 07 5 09	9 16 11 17
	B	3 04	2 02	2 01
July ..	1—A	8 39 10 56	1 46 4 36	10 21 11 18
	B	2 17	2 50	0 57
	2—A	6 59 10 45	2 02 6 25	10 36 12 56
	B	3 46	4 23	2 20

A—Range.

B—Variation between extremes.

Note: 6 steers in November, May, and July, and 7 steers in January and March.

(i) Comparison of of Methods of Observation.

From the field observation sheets, it has been possible to compute figures similar to those which would have been obtained had the group of 6 or 7 head used in this trial been observed at 5-minute intervals on a group basis (the method employed in the South Johnstone trial).

Figures obtained for average daily activities of the group computed from individual continuous observations and group observations at 5-minute intervals are given in Table 22.

There are only small differences between the figures obtained by each method. The greatest variation was 18 minutes (day 2, January) and in the main the variation is of the order of 1-5 minutes.

IV. CONCLUSIONS.

The results obtained indicate clearly that cattle vary their habits from day to day. Whether this is due to idiosyncrasy and/or variation of weather, or a combination of both, is not known. The extrinsic conditions which showed most variation were pasture and weather.

Table 22.

COMPARISON OF METHODS OF OBSERVATIONS—AYR.

(Times in Hours and Minutes.)

Month.	Day.	Grazing.	Loafing.	Lying Down.
November	1—A	6 09	7 33	10 18
(6 head)	B	6 05	7 36	10 19
	2—A	6 40	8 35	8 45
	B	6 41	8 35	8 44
January ..	1—A	5 52	6 03	12 05
(7 head)	B	5 51	6 10	11 59
	2—A	6 14	6 44	11 02
	B	6 32	6 28	11 00
March ..	1—A	5 25	11 32	7 03
(7 head)	B	5 26	11 28	7 06
	2—A	4 46	8 25	10 49
	B	4 44	8 18	10 58
May ..	1—A	10 13	2 33	11 14
(6 head)	B	10 18	2 31	11 11
	2—A	9 33	4 13	10 14
	B	9 31	4 15	10 14
July ..	1—A	10 04	3 13	10 43
(6 head)	B	9 59	3 17	10 44
	2—A	8 48	3 33	11 39
	B	8 44	3 29	11 47

A—Group observations at 5-minute intervals.

B—Continuous individual observations.

Pastures varied in quantity and quality, but the amount of grazing available was always more than adequate. The effect of continuous grazing of small areas on a rotational basis would be to reduce the amount of fodder available on succeeding days. However, from the data obtained there does not seem to be any evidence to suggest that grazing time increased from day to day as a result of this. It does seem, though, that the quantity of pasture available at any period influences the distance a beast will walk to eat its fill. It is not possible to draw conclusions as to the effect of quality of pastures on the grazing habits of cattle.

Weather was the major variant. The effect which changes in the weather may exert would seem to be quite considerable, with temperature and humidity being the most important.

From the observations reported and from a consideration of the results obtained in temperate climates, it would appear that high temperature has the following effects on cattle of the British breeds.

(1) It reduces the amount of grazing time between 8 a.m. and 4 p.m., with a consequent increase between 4 p.m. and 8 a.m.

(2) It restricts total grazing time despite the change from day to night grazing.

(3) It causes long periods to be spent in the shade.

(4) It restricts the time occupied lying down, thus causing an increase in loafing time.

The influence of high temperatures in causing cattle to spend long periods loafing during the heat of the day is very evident, and it is quite definite that cattle prefer to stand or walk about on hot days rather than to lie down for protracted periods. This reaction is logical, as dissipation of body heat, with resultant bodily comfort, would be greater while the beast was standing up than if lying down.

Excessive periods of discomfort due to heat during the day may result in fatigue and so reduce night grazing.

The importance of shade in a tropical environment is emphasised by the amount of use made of it by animals in these trials. Further, the availability of shade influences greatly the distribution of activities and the general reaction to hot conditions.

Idiosyncrasy is very evident, and in any work of this nature the reactions of a group of comparable animals should be the criterion.

Observation of a group of at least six head at 5-minute intervals gives results comparable with those obtained by continuous observation of individuals. The group method of observation permits more cattle to be employed and hence minimises differences due to individuality.

From the results obtained in the course of this work it appears that a study of the grazing habits of various classes of cattle could be of considerable help in selecting animals suited to a tropical environment. This type of investigation could to a large extent provide some explanations as to why one class of cattle is more suited to an environment than another.

V. ACKNOWLEDGEMENTS.

I wish to express my thanks for the help given by the many officers of the Department of Agriculture and Stock who have co-operated to make this work possible and to Miss G. Davey, who prepared the histograms used in this paper.

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THE PRESERVATION OF BOVINE BLOOD FOR THE DETERMINATION OF INORGANIC PHOSPHATE IN THE DIAGNOSIS OF APHOSPHOROSIS.

By K. W. MOIR, B.Sc., Analyst, Chemical Laboratory, Division of Plant Industry.

SUMMARY.

An improved method of preserving and processing bovine blood for the determination of the level of inorganic phosphate is described.

The incomplete precipitation of protein in dilute trichloracetic acid, which is noted particularly at high atmospheric temperatures and which interferes with colorimetric estimation, may be avoided by adding fullers earth and trichloracetic acid to the filtrate prepared for treatment for colorimetric estimation.

The low final concentration of trichloracetic acid attainable by this procedure permits the storage of the blood for several days without appreciable hydrolysis of organic P. compounds to inorganic P.

INTRODUCTION.

The observation of Theiler, Green and Du Toit (1927) that a fall in the inorganic phosphorus (denoted by P.) level in bovine blood preceded any outward clinical symptoms of aphosphorosis provided a useful means of diagnosing aphosphorosis in its early stages.

The method used by these workers for the determination of inorganic P. was precipitation of blood protein with 5% trichloracetic acid, followed by colorimetric estimation of inorganic P. as reduced phosphomolybdate in the trichloracetic acid filtrate. Because inorganic P. is liberated from organic P. compounds with time in whole blood and in trichloracetic acid filtrates of whole blood, the method was of limited usefulness in cases where blood samples took several days to reach the analyst.

Malan (1930) reported that hydrolysis of organic P. compounds to inorganic P. proceeds more slowly in dilute solutions of trichloracetic acid. A final concentration of 2·5% trichloracetic acid in the filtrate enabled blood to be stored for at least eight days and allowed a reasonably accurate diagnosis of aphosphorosis to be made.

OBSERVATIONS.

Attempts by the author to confirm Malan's procedure were unsuccessful, due to cloudiness of the developed, reduced phosphomolybdate blue making matching of colours difficult and inaccurate. This cloudiness, which is due to unprecipitated protein, is more marked at high temperatures. When inorganic P. is determined on blood which has stood for two or three days at high

atmospheric temperatures, protein is precipitated by the molybdate reagent, and appreciable quantities of the reduced phosphomolybdate are adsorbed on the surface of the precipitate. The nature of the unprecipitated protein in dilute trichloracetic acid is changed on standing, for the precipitation cannot be completed by adding further trichloracetic acid.

In attempts to overcome the difficulty caused by cloudiness, the author found that cloudiness in the developed solution may be prevented by adding a small quantity of fullers earth and trichloracetic acid to the filtrate immediately before adding the analytical reagents. This procedure permits a final concentration of 1·5% trichloracetic acid. At this concentration, the rate of liberation of inorganic P. from organic P. compounds is very slow.

The addition of isotonic saline to the trichloracetic acid preservative facilitates the subsequent filtration of the protein mass.

An indication of the suitability of the method for blood which has been stored for some time is given by the fact that in 18 samples of blood processed after storage at 18°C. for two weeks, the average increase in inorganic P. was 0·15 mg.P. per 100 ml. blood, with a maximum increase of 0·3 mg.P. in two samples (Table 1). It is unlikely that under field conditions the period required for transport and storage of blood samples would be as long as 14 days. In most cases accurate determination may be made three to four days after collection and processing of the blood sample. As might be expected, the hydrolysis proceeds more readily at high temperatures. At 37°C. the same average increase was observed in one week. No measurable hydrolysis occurs in refrigerated samples for the same period.

Table 1.

Phosphorus Levels in Blood Samples Preserved in 1·5% Trichloracetic Acid (mg. P. per 100 ml. of blood)

No.	Initial inorganic P. levels.	Inorganic P. levels after 14 days at 18°C.	Increase in inorganic P. levels.	Hydrolysable P. ester.
1	5·1	5·3	0·2	1·7
2	3·8	3·9	0·1	1·4
3	4·8	4·9	0·1	1·5
4	2·2	2·2	0	1·0
5	2·6	2·6	0	1·2
6	3·5	3·6	0·1	1·2
7	2·8	2·9	0·1	1·3
8	3·7	3·7	0	1·3
9	6·2	6·4	0·2	1·7
10	4·3	4·5	0·2	1·6
11	4·4	4·6	0·2	1·6
12	4·8	5·0	0·2	1·5
13	3·6	3·6	0	1·4
14	4·0	4·2	0·2	1·6
15	5·3	5·6	0·3	2·0
16	4·4	4·6	0·2	1·5
17	4·1	4·3	0·2	1·5
18	5·0	5·3	0·3	1·8

Malan (1930) observed that the hydrolysis of phosphorus esters in a fixed concentration of trichloracetic acid varies irregularly in blood from different animals of the same species although he did not report the temperatures at which individual samples were kept. He postulated that the quantity of the organic acid soluble P. present was a contributing factor to the variability noted but did not attempt to confirm this statement.

This aspect was examined and the conclusions reached are summarized below:—

(i) The total organic acid soluble P. can be differentiated into a hydrolysable and an unhydrolysable fraction. The hydrolysable fraction was determined by heating 10 ml. of the filtrate from 10 ml. of blood in 40 ml. of 8% trichloracetic acid with 1 ml. of 20% H_2SO_4 for one hour at 100°C. After one hour there was no further increase in inorganic P. In 20 blood samples, the concentration of the hydrolysable P. ester fraction varied between 30% and 60% of the total P. ester.

(ii.) The rate of hydrolysis in blood in a fixed concentration of trichloracetic acid at constant temperature tends to increase as the concentration of hydrolysable P. ester increases.

(iii) Low levels of inorganic P. tend to be associated with low levels of hydrolysable P. ester.

From these observations, it is evident that the hydrolysis of P. esters generally proceeds more slowly in blood with low levels of inorganic P. In the 18 blood samples mentioned above, the average concentration of hydrolysable P. ester corresponded to 1.5 mg.P. per 100 ml. of blood (see Table 1). The two samples with the maximum increases of 0.3 mg.P. in two weeks at 18°C. coincided with the highest concentration of hydrolysable P. ester (1.8 mg. and 2.0 mg.P. per 100 ml. blood) and normal inorganic P. levels of 5.0 mg. and 5.3 mg.P. per 100 ml. blood.

PROCEDURE.

For the preservation of blood for inorganic phosphate determination, 2 oz. bottles containing 35 ml. of 2.0% trichloracetic acid and 0.9% NaCl are made up for use in the field. (At present there is some doubt as to the keeping properties of trichloracetic acid, which gives a free chloride test on standing in dilute solution. Liberated HCl would increase the $[H]+$, which may increase the hydrolysis of P. esters. However, from preliminary work, the above solution is considered sufficiently stable for probably two or three months.)

To the prepared bottles, 10 ml. of blood containing not more than 0.1 g. sodium citrate is added and the contents shaken.

The samples are returned to the laboratory, and immediately prior to analysis 5 ml. of 20% trichloracetic acid is added and the contents mixed. Approximately 0.5 g. of fullers earth is then added and the contents shaken and allowed to stand for at least two minutes before filtering through a No. 2 Whatman filter paper (phosphate free).

To 10 ml. of the clear filtrate is added 4.5 ml. (from a 10 ml. measuring cylinder or burette) of the following reagents mixed in equal proportions by volume immediately before use:—

(i) Brigg's reagent: 25 g. ammonium molybdate is dissolved in water with warming and made to 200 ml. This is mixed when cold with a cooled solution of 75 ml. of concentrated H_2SO_4 diluted to 300 ml. of water.

(ii) 20% aqueous sodium sulphite.

(iii) 1% aqueous hydroquinone.

The volume is made to 20 ml. and compared in a visual colorimeter after 30 minutes, but not more than 45 minutes, against 2 ml. of standard phosphate solution containing 50 μg.P. per ml.

SELECTION OF FULLERS EARTH.

The classification and physical properties of eight different batches of fullers earth and their relative capacities for adsorbing protein are given in Table 2. The blanks of 0.5 g. of these samples are expressed as mg.% P. These blanks refer to the calculated error in mg.P. per 100 ml. of blood when the above procedure is used.

Table 2.

Examination of Samples of Fullers Earth.

Sample.	Classification.	Colour.	Texture.	Relative Adsorption.	Blank Mg%. P.
1	B.D.H. for adsorption ..	Grey ..	Fine powder	++	1·2
2	B.D.H. for adsorption ..	Red-brown ..	Fine powder	+	0·2
3	B.D.H. for adsorption ..	Grey-white ..	Granular ..	+	5·0
4	B.D.H. for adsorption ..	Brown ..	Lump ..	++	0·05
5	B.D.H. for adsorption ..	Brown ..	Fine powder	++	0·10
6	B.D.H. for adsorption ..	Brown ..	Fine powder	++	0·10
7	B.D.H. for adsorption ..	White ..	Fine powder	—	0·05
8	D.B.H. for adsorption ..	White ..	Fine powder	—	0·40

The batches of fullers earth with good adsorptive properties and with low blanks (<0.1 mg.%P.) could be used directly by approximating without weighing the 0.5 g. fullers earth and subtracting this blank in the determination of inorganic P., without significant error.

While the selection of fullers earth with the most desirable properties might readily be achieved by prior testing of several samples, the following method for eliminating this blank without loss in adsorptive properties was devised.

200 g. of fullers earth is stirred into a uniform paste with 250 ml. of concentrated H_2SO_4 (S.G. 1.84) and immediately poured into 3–4 litres of water. The fullers earth is washed four times with tap water by decantation and finally with distilled water. The product is then filtered through a buchner funnel, dried at 100°C. and ground to a fine powder.

It is recommended that the fullers earth to be used for adsorption, whether directly or treated, should be examined for the following characteristics under precisely the conditions for the analysis of blood.

The blank, if any, on the fullers earth should be:

(i) Proportional to the amount of fuller's earth used.

(ii) Independent of the concentration of P. to be determined.

(iii) Independent of the time, within reasonable limits, in which the fullers earth is in contact with the trichloracetic acid.

(iv) Constant for small changes in the trichloracetic acid concentration.

In addition, the rate of development of reduced phosphomolybdate in a standard P. solution treated with fullers earth should be the same as that of an untreated P. standard. A curve relating the development of colour to time may be determined in a photoelectric colorimeter at 595 mμ against a blank of the reagents at 10, 20, 30 and 40 minutes development time.

All samples of fullers earth examined conformed to the above conditions, with the exception of the treated sample, which gave a very slight asymmetric curve for the development of colour. The difference was, however, insignificant at 45 minutes development time.

The minimum amount of fullers earth required to clarify blood filtrates under the most unfavourable conditions of storage anticipated should be determined.

DISCUSSION.

In the diagnosis of aphosphorosis in cattle, a sufficiently good assessment of the phosphate status of the blood may be made if the error in the inorganic P. level does not exceed 0.3 mg.P. per 100 ml. blood.

The modification of Malan's method developed by the author permits a determination of inorganic P. within this margin of error, even after several days' storage at atmospheric temperature. Because hydrolysis in blood with a low inorganic P. level proceeds very slowly, processed samples of such blood may be kept for as long as two weeks and still yield reliable determinations.

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STUDIES OF THE COCCOIDEA. 2. REVISION OF SOME OF THE AUSTRALIAN ASPIDIOTINI DESCRIBED BY MASKELL.

By A. R. BRIMBLECOMBE, M.Sc., Senior Entomologist, Division of Plant Industry.

SUMMARY.

Examination of type specimens of some of the Aspidiotini from Australia described by Maskell and other relevant material has enabled the following conclusions.

Aspidiotus acaciae **Morgan,** Pseudaonidia junctiloba **Marlatt and** Aspidiotus junctilobius **Froggatt are synonyms of** Aspidiotus eucalypti **Maskell, which is correctly placed in the genus** Neomorgania **and now becomes the genotype.**

The variety comatus **Maskell of** Aspidiotus eucalypti **Maskell represents a distinct species and belongs to the genus** Pseudotargionia.

Aspidiotus virescens **Maskell is a synonym of** Diaspis fimbriata **Maskell which is now made the genotype of a new genus** Megaspidiotus.

The characters of Aspidiotus casuarinae **Maskell conform with those of the genus** Pseudaonidia **but as the type appears to be an immature adult further material is needed for examination.**

These species have been re-described and re-illustrated.

INTRODUCTION.

The study of the Coccoidea in Queensland has involved a review of many of the earlier described Australian species. In a number of instances the descriptions and illustrations of these insects are inadequate for detailed taxonomic comparisons. Before identification can be made with confidence, type material of these species must be critically examined and for the benefit of future workers new descriptions and illustrations are necessary. This work is proceeding and has been assisted by the loan of Maskell's types from the Department of Science and Industry, Nelson, New Zealand; "part-type" material in the Green collection from the South Australian Museum; and cotypes, named and unnamed material from the Division of Entomology, C.S.I.R.O., Canberra.

The Maskell material dealt with in this paper consisted of slides, but the specimens were not well cleared before mounting and even with phase contrast examination some characters were not easily discerned. The study of the material, however, has assisted in determining the status of each of the species and has led to the establishment of new synonymy and a new genus.

Neomorgania eucalypti (Maskell).

(Figs. 1 and 2)

Type locality and host.—South Australia on *Eucalyptus* sp.

Synonymy.—

1888: *Aspidiotus eucalypti* Maskell: Transactions of the Royal Society of South Australia: p. 102.

1889: *Aspidiotus acaciae* Morgan: Entomological Monthly Magazine: 25: p. 353.

1901: *Targionia acaciae* (Morgan): Leonardi: Revista di Patalogia Vegetale: 8: p. 308.

1901: *Targionia eucalypti* (Maskell): Leonardi: Revista di Patalogia Vegetale: 8: p. 310.

1908: *Pseudaonidia eucalypti* (Maskell): Marlatt: Proceedings of the Entomological Society of Washington: 9: p. 135.

1908: *Pseudaonidia junctiloba* Marlatt: Proceedings of the Entomological Society of Washington: 9: 135.

1914: *Aspidiotus* (*Targionia*) *acaciae* Morgan: Froggatt: Agricultural Gazette of New South Wales: 25: p. 131.

1914: *Aspidiotus* (*Targionia*) *eucalypti* Maskell: Agricultural Gazette of New South Wales: 25: p. 312.

1914: *Aspidiotus junctilobius* Froggatt: Agricultural Gazette of New South Wales: 25: p. 315.

1921: *Neomorgania acaciae* (Morgan): MacGillivray: The Coccidae: p. 458.

1921: *Neomorgania junctiloba* (Marlatt): MacGillivray: The Coccidae: p 458.

1921: *Neomorgania eucalypti* (Maskell): MacGillivray: The Coccidae: p. 458.

The variety *propinquus* Maskell was determined by Leonardi (1901) as a synonym of the type *acaciae*. This determination remains to be confirmed.

Material examined.—From the Maskell collection, Department of Science and Industry, New Zealand, a slide specimen labelled "Aspidiotus eucalypti, adult female, South Australia, 1888, W.M.M." The new description given is from this specimen.

From the South Australian Museum unmounted material labelled "Aspidiotus junctiloba Green, on Acacia, Shepparton, Victoria"; and "Aspidiotus junctilobius Frogg. on Pittosporum phillyroides, Mallee, J. E. Dixon."

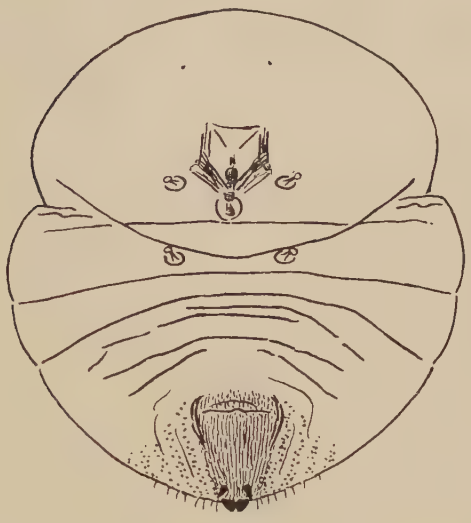

Fig. 1.

Neomorgania eucalypti (Mask.). Outline of adult female. (x 70).

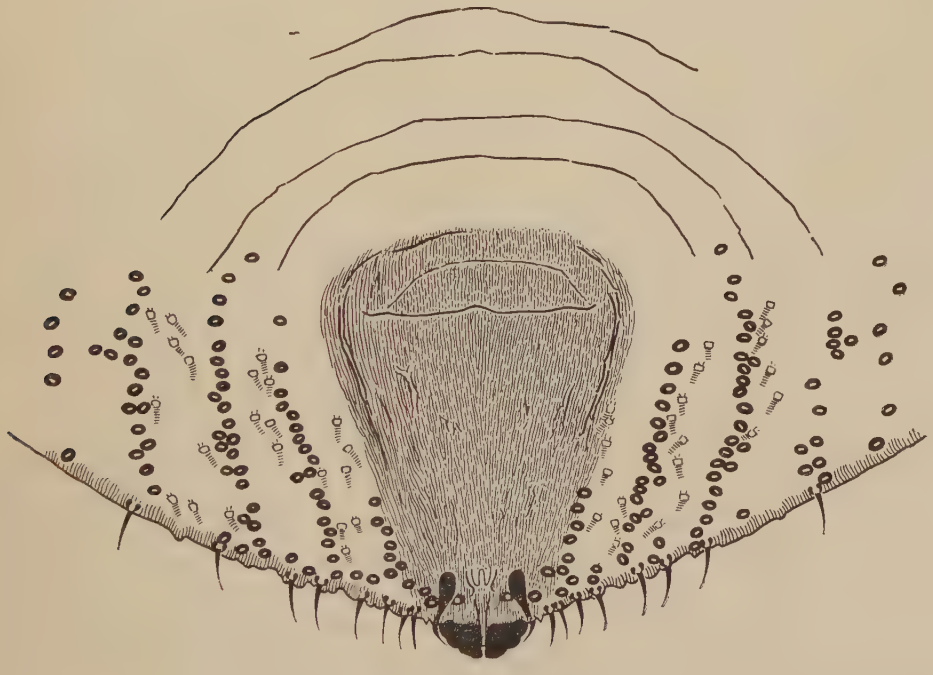

Fig. 2.

Neomorgania eucalypti (Mask.) Enlargement of pygidium. (x 250).

From the Froggatt collection of the Division of Entomology, C.S.I.R.O., Canberra, unmounted material labelled "Acacia stenophylla, Euston, N.S.W., 20.10.28, W.W.F."; and "Willow myrtle, Lake Hattah, Victoria, W.W.F."

Recognition characters.—Adult female subcircular with a definite thoracic constriction, length and width of the mounted specimen 0.8 mm. Pygidium not differentiated. Median lobes fused basally but divided dorsally by an anal groove, triangular, as broad as long, with indentations on the external margin. Other lobes absent. Basal scleroses absent. Paraphyses single and adjacent to the median lobe in each first interlobal area,* dilated and length slightly exceeding that of the lobe. An incipient simple plate in the first interlobal space.* Spines longer than the lobes except for a short one adjacent to and obscured by the lobe, curved with the outline of the lobe. Macroducts short and small, orifices in segmental series, with a few intervening near the margin, 11 or 12 in the first furrow,* 18 or 19 in the second and 23 or 24 in the third. Perivulvar pores absent. Anus small, within an inverted V with a groove directed between the lobes. Pygidial margin anterior to the lobes slightly crenulate. A tessellated fingerprint chitinization occurs on all parts of the body except for an irregular reticulation in the median pygidial area.

Notes.—The characters shown by Maskell's type specimen place it is the genus *Neomorgania* which is in agreement with the designation of the species by MacGillivray.

The specimens determined as *Pseudaonidia junctiloba* by Marlatt were labelled "Aspidiotus junctiloba Green on Acacia, Shepparton, Victoria," and therefore are part of the same material as those in the South Australian Museum. Green's name, being a label name only, has no status and Marlatt, by mentioning some distinguishing features, is the authority for the species.

MacGillivray established the genus *Neomorgania* for the three species *junctiloba* Marlatt, *acaciae* Morgan and *eucalypti* Maskell, but failed to designate the genotype. Ferris (1937) assigned *Pseudaonidia junctiloba* Marlatt to this position but used *Aspidiotus junctilobius* Froggatt for the genotype illustration, assuming these two species to be synonymous. Later Ferris (1941) listed Froggatt's species as the genotype.

A comparison between *junctiloba* Marlatt, as represented by the South Australian Museum material, and *acaciae* Morgan, as illustrated by Laing (1929) from a cotype in the British Museum, shows that the two names represent the same insect. Furthermore, a comparison between "*Aspidiotus junctilobius* Froggatt" from the South Australian Museum and Laing's illustration also shows that only one insect is involved. This evidence, together with that provided by Ferris, is taken as demonstrating that *junctiloba* Marlatt and *junctilobius* Froggatt are synonymous with *acaciae* Morgan.

* NOTE.—McKenzie (1939) is followed for the notation of the duct furrows, and the same notation is now used for the interlobal areas and spaces.

The re-description of Maskell's type specimen now shows that *acaciae* Morgan as illustrated by Laing is a synonym of *eucalypti* Maskell. Consequently *eucalypti* Maskell becomes the genotype of *Neomorgania* and this genus is monotypic.

It may be more than coincidence that *junctilobius* Froggatt described from Whitton, New South Wales, has the same locality as specimens from *Eucalyptus* sp. determined by Maskell (1893) as *acaciae* Morgan.

Pseudotargionia comatus (Maskell) new combination.

(Figs. 3 and 4)

Type locality and host.—Australia: Melbourne on *Eucalyptus viminalis.*

Synonymy.—

1896: *Aspidiotus eucalypti* var. *comatus* Maskell: Transactions of the New Zealand Institute 1895: 28: p. 385.

1901: *Targionia eucalypti* var. *comatus* (Maskell): Leonardi: Revista di Patalogia Vegetale: 8: p. 311.

Material examined.—A slide specimen labelled "Aspidiotus eucalypti var. comatus, adult female, 1895, W.M.M.", and a number of Queensland specimens which are to be recorded in a later article.

Recognition characters.—Adult female very broadly turbinate, with a deep thoracic constriction, length of slide mount 0.9 mm., width 0.8 mm. Pygidium very broad basally, almost transversely elliptical in shape. Three pairs of lobes. Median lobes conspicuous, yoked basally, separated by a third of the width of the lobes, margins entire, sides subparallel, apex broadly rounded. Second pair of lobes as small triangular points, third similar to the second but smaller. Basal scleroses absent. Paraphyses on the median side of the first and second interlobal areas. A small single simple plate in the first interlobal space, three similar plates in the second space. Spines conspicuous, first pair of uneven length, the dorsal one slightly longer than the median lobes, and others progressively longer. Macroducts few, small and short, orifices small. Perivulvar pores absent. Anus very small, a lobe's length from the median lobe base, within an inverted V, with an anal groove directed between the median lobes. Pygidial margin beyond the third lobes finely crenulate. Median pygidial area with an irregular reticulate light chitinization, otherwise with a fingerprint chitinization with a similar but lighter pattern over the remainder of the body.

Notes.—Some of the characters are difficult to discern on the partly cleared, unstained specimen but there is sufficient evidence, supported by the local material, to show that this insect cannot be a variety of *Neomorgania*

Fig. 3.

Pseudotargionia comatus (Mask.). Outline of adult female. (x 70).

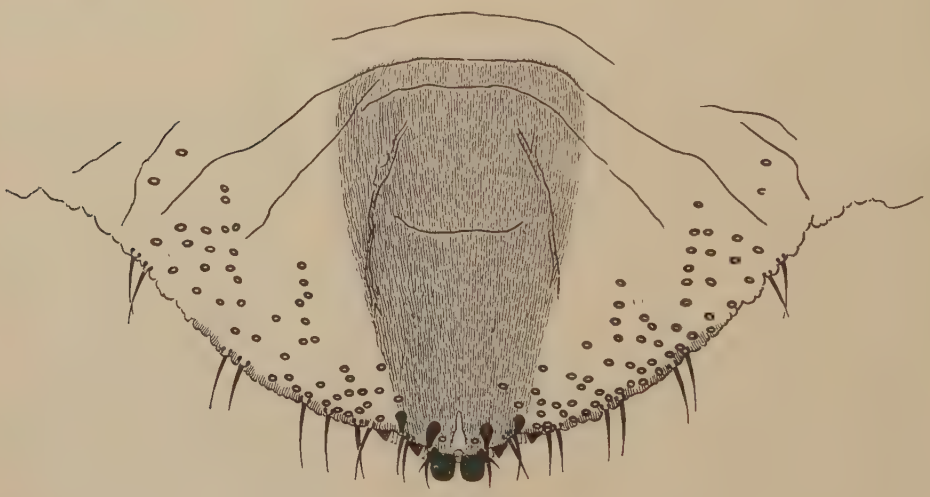

Fig. 4.

Pseudotargionia comatus (Mask.). Enlargement of pygidium. (x 215).

eucalypti (Maskell). Of the established genera, it conforms most closely to *Pseudotargionia*, in which it is now placed. Marlatt (1908), when placing the species *eucalypti* in the genus *Pseudaonidia*, stated: "The variety *comatus* Maskell has no valid status as determined by careful examination of authentic material." An examination of the type slides of both *eucalypti* and the variety *comatus* shows however that the two represent distinct species. Fuller (1899) was afraid that his *perniciosus* var. *eucalypti* might be in confusion with Maskell's *comatus*, but again a different insect is involved.

Megaspidiotus new genus.

Genotype.—Diaspis (?) *fimbriata* Maskell, 1893: Transactions of the New Zealand Institute 1892: 25: p. 208.

Characters.—Body of adult female with a thoracic constriction, anterior and posterior portions subequal in length, anterior portion wider, dome shaped, posterior portion subtriangular or margins broadly curved. Three pairs of lobes, second and third pairs varying slightly in size and shape from the median. Median lobes only with basal scleroses. Paraphyses absent. Macroducts short but broad, orifices large. Plates numerous and conspicuous, extending on most of the pygidial margin, broadly fimbriate. Perivulvar pores present. Anus moderately large.

Notes.—The large size, constricted thorax and profuse plates are not typical of the genus *Aspidiotus* with which *Megaspidiotus* has closest affinity. When describing the species *fimbriata* Maskell (1893) was rather puzzled about its generic position, and while explaining that he believed it to be correctly placed in the genus *Diaspis*, a question mark was included in the published name. The species *virescens* here regarded as a synonym was placed by Maskell (1896) in *Aspidiotus*.

Megaspidiotus fimbriatus (Maskell).

(Figs. 5 and 6)

Type locality and host.—Australia: Near Sydney on *Eugenia smithii.*

Synonymy.—

1893: *Diaspis* (?) *fimbriata* Maskell: Transactions of the New Zealand Institute 1892: 25: p. 208.

1896: *Aspidiotus virescens* Maskell: Transactions of the New New Zealand Institute 1895: 28: p. 384.

1897: *Aspidiotus fimbriatus* (Maskell): Cockerell: United States of America Department of Agriculture, Technical Series No. 6: p. 26.

1899: *Aspidiotus* (*Evaspidiotus*) *fimbriatus* (Maskell): Leonardi: Revista di Patalogio Vegetale: 7: p. 58.

1899: *Aspidiotus* (*Evaspidiotus*) *virescens* Maskell: Leonardi: Revista di Patalogia Vegetale: 7: p. 64.

Material examined.—Two specimens on a slide labelled "Diaspis fimbriata females and puparium, Australia, 1892. W.M.M." The re-description given is from this slide.

A slide specimen labelled "Aspidiotus virescens, adult female, 1895, W.M.M."

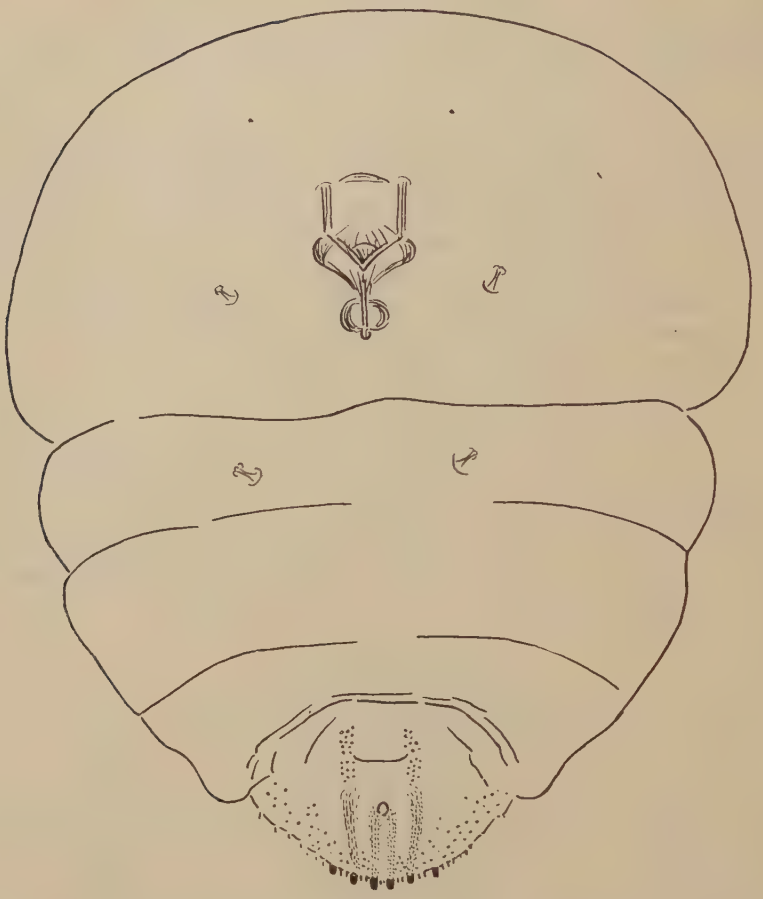

Fig. 5.

Megaspidiotus fimbriatus (Mask.). Outline of adult female. (x 70).

Recognition characters.—Adult female broadly turbinate with lateral constrictions, length of slide specimens 1·4 and 1·6 mm., width 1·2 and 1·4 mm. Pygidium subcircular to transversely elliptical in the older specimen which is the larger (and contains eggs). Three pairs of lobes. Median pair longer than wide, slightly constricted at the base and narrowing apically to a rounded point, which is not so pronounced in the older specimen, separated by more than the lobe width. Second pair of lobes similar to the median but slightly smaller and less indented on the inner margin, separated from the median by twice the width of the latter. Third pair similar but smaller, separated from the second pair by three times the median lobe width. Basal scleroses from the median lobes only. Paraphyses absent. Plates conspicuous, longer than the lobes, extending forwards on about two thirds of the pygidial margin, two between the median lobes, two in the first interlobal space and three in the second space, all of these broad, apically dilated and fimbriate;

Fig. 6.

Megaspidiotus fimbriatus (Mask.). Enlargement of pygidium. (x 220).

plates numerous beyond the third lobe, nine and ten of similar broad, fimbriate shape, decreasing slightly in size in the younger specimen with a further two or three of irregular shape, eleven beyond the third lobe in the older specimen with about five of irregular shape. Spines short and inconspicuous. Macroducts broad, slightly less than half the distance from the median lobes to the anus, orifices large, arranged in the typical manner of *Aspidiotus*, one opening in the median area, nine or ten in the first duct furrow, about fifteen in the second, and about eighteen in the third. Perivulvar pores in four or five groups, anterior median 5 (old specimen), anterior laterals 11 to 13, posterior 10 to 13. Anus of moderate size nearer to the median lobes than to the anterior of the pygidium.

Notes.—The type locality and host record for both *Diaspis* (?) *fimbriata* and *Aspidiotus virescens* are near Sydney, New South Wales, on *Eugenia smithii*. A comparison of the two slides shows that the characters presented by *Aspidiotus virescens* agree with those of *Diaspis* (?) *fimbriata* except that anterior to the third lobe there are twelve broad fimbriate plates plus possibly five others; there appear to be eleven orifices in the first duct furrow, seventeen to nineteen in the second and about twenty in the third; and the anterior lateral perivulvar pores number 16 and 18, the posterior 9 and 13. These differences are not significant and might in part be due to the poor slide mounts.

Pseudaonidia casuarinae (Maskell).

(Figs. 7 and 8)

Type locality and host.—New South Wales: Albury on *Casuarina equisetifolia.*

Synonymy—

1894: *Aspidiotus casuarinae* Maskell: Transactions of the New Zealand Institute 1893: 26: p. 26.

1901: *Targionia casuarinae* (Maskell): Leonardi: Revista di Patalogia Vegetale: 8: p. 314.

1908: *Pseudaonidia casuarinae* (Maskell): Marlatt: Proceedings of the Entomological Society of Washington: 9: p. 135.

1914: *Aspidiotus* (*Targionia*) *casuarinae* Maskell: Froggatt: Agricultural Gazette of New South Wales: 25: p. 134.

1921: *Targaspidiotus casuarinae* (Maskell): MacGillivray: The Coccidae: p. 447.

Material examined.—A slide specimen labelled "Aspidiotus casuarinae, adult female, 1893; W.M.M."

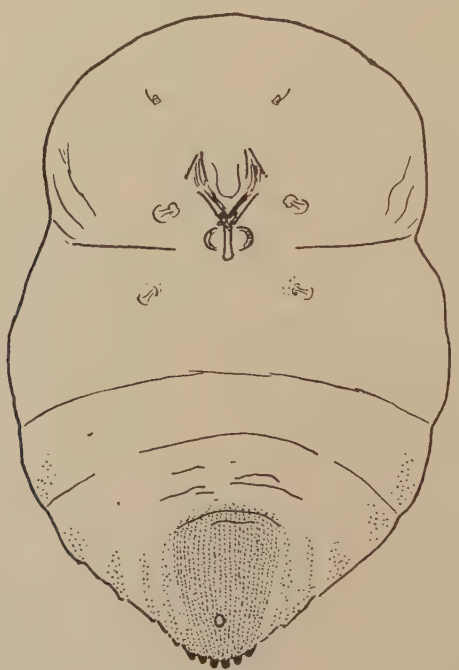

Fig. 7.

Pseudaoinidia casuarinae (Mask.). Outline of adult female. (x 70).

Recognition characters.—Adult female somewhat oval, with a thoracic constriction, and narrowing posteriorly. Length of slide specimen 1·2 m.m., width 0·8 mm. Pygidium very broad basally, not differentiated, apex obtuse. Three pairs of lobes. Median pair slightly longer than wide, sides subparallel, apex rounded, separated by slightly less than the lobe width. Second pair of lobes shorter than the median, but of comparable width, apex with a small point, slightly convergent, the posterior outer surface more curved than the inner, separated from the median by the lobe width. Third pair of lobes

Fig. 8.

Pseudaonidia casuarinae (Mask.). Enlargement of pygidium. (x 240).

subequal to the second, apex pointed, convergent, separated from the second by slightly more than the median lobe's width. Basal scleroses absent. Paraphyses absent. Plates present in the median, first and second interlobal spaces, as a pair in the median and first spaces, shorter than the lobes, apparently with the apex bifid, number and nature of those in the second space not distinct. Spines shorter than the lobes. Macroducts broad, length less than half the distance between lobes and anus, orifices large, two in the median furrow, 10-11 in the first furrow, possibly between 20 and 25 in the second furrow, numerous in other furrows. Perivulvar pores absent. Anus small, within an inverted V, one third of the pygidial length from the median lobes. Pygidial margin irregular anterior to the third lobes. Body surface with faint fingerprint chitinization.

Notes.—There is the impression of a small pair of paraphyses in the median interlobal space. The broken nature of the pygidial margin might indicate a fourth pair of lobes. These and the other features mentioned are in general agreement with the characters of the genus *Pseudaonidia* in which this species was placed by Marlatt. The specimen probably is an immature adult and the shape presented may be due to lack of expansion and chitinization which would develop with age and feeding. The number of duct orifices, however, is excessive for the genus and perivulvar pores are absent; therefore further discussion is deferred until additional material is available.

ACKNOWLEDGEMENTS.

The action of Dr. Cottier (Senior Entomologist, Department of Science and Industry, New Zealand) in making Maskell's types available for study is appreciated. Thanks are due also to Mr. Herbert M. Hale (Director, South Australian Museum) and Dr. A. J. Nicholson (Chief, Division of Entomology, C.S.I.R.O.) for the loan of material from their institutions. Mr. W. Manley, Departmental Illustrator, made the drawings for all the figures.

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(Received for publication Nov. 4, 1954.)

BLUE OAT MITE CONTROL.

The status of the blue oat mite (*Penthaleus major* (Duges)) as a pest in Queensland has been discussed by Smith (1928), in Vol. III. of the Queensland Agricultural and Pastoral Handbook (Officers of the Department of Agriculture and Stock 1951) and by May (1954).

During the late winter and early spring of 1953, this mite heavily infested wheat fields in the Bongeen district, Darling Downs. This opportunity was taken to set out two 8 x 3 randomised block trials, eight weeks after germination, using BHC, DDT and dieldrin. A plot size of 1/100th acre was used.

When treatments were applied on July 2, subsoil moisture was adequate but surface soil moisture was low. Some two inches of rain fell eight weeks later.

Pest survival was assessed as plot infestation ratings as follows:— 0 = 0; 1 = 1 to 5; 2 = 6 to 10; 3 = 11 to 15; 4 = 16 to 20; 5 = >20 mites recorded. Counts were made on two widely spaced rows of plants in each plot, 22 ft. 10 in. in length, during late afternoon as mites emerged to feed on the leaves. Yields were taken on November 17 in one trial only, which was harvested for grain and straw weights with a hand-operated power mower.

Results and treatment details are given in Tables 1 and 2.

Table 1.

Results of Trial 1.

Treatments.	Ratings.				Yield.*
	At 5 Days.		At 12 Days.		
	Transformed Mean. ($\sqrt{x+\frac{1}{2}}$.)	Equivalent Mean.	Transformed Mean. ($\sqrt{x+\frac{1}{2}}$.)	Equivalent Mean.	Bulk Weight (Lb./Plot).
BHC 1½ oz. *g.i.*/ac.	1·39	1·4	1·44	1·6	19·00
BHC 1 oz. *g.i.*/ac.	2·04	3·7	1·82	2·8	19·50
BHC ½ oz. *g.i.*/ac.	1·72	2·5	1·90	3·1	18·50
DDT ½ lb./ac.	·71	0·0	·71	0·0	18·50
DDT ¼ lb./ac.	1·22	1·0	·71	0·0	19·00
DDT ¼ lb./ac. + BHC ½ oz. *g.i.*/ac.	1·00	0·5	1·05	0·6	20·17
Dieldrin ½ lb./ac.	1·64	2·2	1·34	1·3	19·00
No treatment	2·19	4·3	2·20	4·3	17·50
Differences necessary for significance { 5%	·72		·53		
Differences necessary for significance { 1%	1·00		·74		

* In the analysis of variance the value for F was not significant.

Table 2.

RESULTS OF TRIAL 2.

Treatments.	Ratings.			
	At 12 Days.	At 26 Days.	At 54 Days.	
	Equivalent Mean.	Equivalent Mean.	Transformed Mean. ($\sqrt{\times + \frac{1}{2}}$.)	E quivalent Mean.
BHC 1½ oz. *g.i.*/ac.	5·0	4·7	2·27	4·7
BHC 1 oz. *g.i.*/ac.	5·0	4·7	2·35	5·0
BHC ½ oz. *g.i.*/ac.	4·7	3·7	2·27	4·7
DDT ½ lb./ac.	0·0	1·3	1·46	1·6
DDT ¼ lb./ac.	0·3	0·3	1·46	1·6
DDT ¼ lb./ac. + BHC ½ oz. *g.i.*/ac.	0·3	0·0	1·64	2·2
BHC 1 oz. *g.i.*/ac. + detergent 1½ pt./100 gal.	4·7	3·7	1·82	2·8
No treatment	5·0	4·3	2·27	4·7
Differences necessary for significance { 5%	+	+	·52	
Differences necessary for significance { 1%			·72	

\+ Treatments containing DDT obviously less than remainder.

DDT proved superior to BHC and dieldrin and a dosage rate of ¼ lb./acre reduced the population as effectively as ½ lb./acre. This effect persisted for almost two months after spraying. Under the conditions experienced, yield differences could not be expected in these trials (see May 1954), as plants were continually dependent on the seedling root system till the early September rain.

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—A. W. S. MAY.

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THE CONTROL OF GRASS CATERPILLARS.

Psara licarsisalis (Walk.), under the common name of the grass moth, has been discussed in the Queensland Agricultural and Pastoral Handbook (Officers of the Department of Agriculture and Stock 1951).

Although this insect has a State-wide distribution it is responsible for serious damage to pastures and lawns only in the south-eastern coastal areas of the State in the late summer and autumn. Recent Departmental records list severe outbreaks in 1947 and 1949, but during the grass caterpillar outbreak in the autumn of 1947 *Prodenia litura* (F.) appeared as the predominant species. This occurrence is rather unusual in Queensland but was recorded again during March and April of 1954.

Although for some years DDT has been used successfully to control *P. licarsisalis* and several Noctuids (Passlow 1952; May 1953; May and Passlow 1954), this opportunity was taken to establish trials against *P. litura* functioning as a grass pest.

A typical example of this work is as follows. An 8 x 4 randomised block with a plot size of 10 feet square was set out at Tingalpa where kikuyu grass (*Pennisetum clandestinum* Hochst.) and couch grasses (*Digitaria didactylon* Willd. and *Cynodon dactylon* Pers.) were being grown and harvested for poultry green feed. The soil, though on a slope with an easterly aspect, was poorly drained; the ground cover in all places was at least four to six inches deep.

Table 1.

Treatment.	2-Day Count.		5-Day Count.
	Transformed Mean.*	Equivalent Percentage Survival.†	Percentage Survival.†
DDT ¼ lb./ac.	13·6	5·5	3·1
DDT ½ lb./ac.	13·7	5·6	1·3
DDT 1 lb./ac	8·4	2·1	0·9
Dieldrin ⅛ lb./ac.	27·6	21·5	2·7
Dieldrin ¼ lb./ac.	17·8	9·3	0·7
Dieldrin ½ lb./ac.	12·9	5·0	0·0
Differences necessary for significance { 5%	9·2	..	Not analysed.
Differences necessary for significance { 1%	12·8	..	

* Inverse sine transformation.

† Survival percentages, based on pre-treatment counts on April 2, have been adjusted to 100% survival for the control plots. The observed survival percentages on the control plots were 74% and 55% on the second and fifth days respectively.

In the assessment of larval populations, counting was facilitated by spreading wet Chapman bags in each plot late in the afternoon. Next morning the larvae beneath these bags were counted. Details of the spray treatments, dosage rates as pounds of active ingredient per acre, and the results are given in Table 1.

In these trials all treatments gave satisfactory control. Under the wider application of commercial practice, DDT at the dosage rate of $\frac{1}{4}$ lb. per acre, increased to $\frac{1}{2}$ lb. per acre when a thick body of grass was present, was found satisfactory under the ruling prices of the insecticides concerned.

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—B. R. CHAMP.

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